CEMENT AND LIME MANUFACTURE

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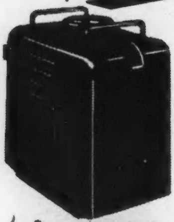

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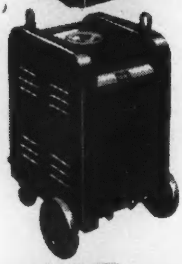

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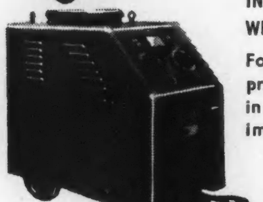

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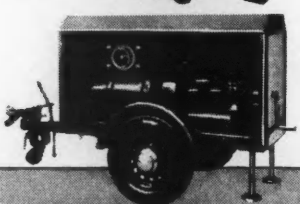

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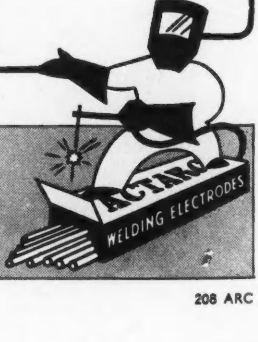

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New Cement Works in Uganda.

TREATMENT OF LIMESTONE CONTAINING PHOSPHORIC ANHIDRIDE.

By **H. SWIFT,** OF HENRY POOLEY, CONSULTING ENGINEERS.

Introduction.

To provide the cement needed for the construction of the Owen Falls dam, and also to promote the development of the territory, Uganda Cement Industry has established a cement works near Tororo on the Uganda-Kenya border and some 150 miles east of Kampala. Messrs. Henry Pooley are the consulting engineers. Investigations made in 1948 showed that limestone deposits in the district, although containing in varying quantities phosphoric anhydride in the form of apatite, would be suitable provided that the apatite content could be reduced so that it did not exceed 1 to 2 per cent. in the clinker. Large-scale experiments were carried out in England by the wet and dry processes of flotation. In the wet process, attempts at separation either by floating the limestone with soaps or the apatite with cation-active reagent were unsuccessful and were discontinued. In the dry process the limestone was burnt and the resultant lime slaked with sufficient water fully to hydrate it without forming lime putty, and then passing the product through an air separator where the lighter slaked lime was separated from the heavier unslaked lime. During the preliminary experiments highly satisfactory results were achieved, as follows:—

	P_2O_5 in stone before separation (per cent.)	P_2O_5 in hydrate after separation (per cent.)
Sample No. 1	1·2	0·1
,, No. 2	4·0	1·0
,, No. 3	5·8	0·58

Uganda Cement Industry obtained from storage in Trieste an unused Polysius dry-process plant capable of producing 60,000 tons of cement a year at sea level;

this plant was made in 1941, for making Portland blastfurnace cement from limestone, shale, and blastfurnace slag. As this plant required only minor modifications to meet local conditions, cement will be available for the Owen Falls dam at least one year earlier than would have been possible had it been necessary for plant to be manufactured. The plant is modern in all respects and is provided with the latest type of electrical dust-precipitation equipment.

The site of the works is at Sukulu, about five miles from Tororo, and has rail access to the Kenya & Uganda Railway on the main line between Kampala and Nairobi; it is thirteen miles from the Kampala-Kisumu main road, and twenty-nine miles from the port of Mjanji on lake Victoria. Thus the site is admirably situated for rail, road, or lake transport.

Raw Materials.

LIMESTONE.—Two limestone deposits are available, one at Tororo and the other at Sukulu; the deposit at Tororo is being worked first, and the deposit at Sukulu will be used later. The deposit at Tororo is in the form of a hill some 300 ft. high with very little overburden, and stripping is done by hand. The limestone is won by blasting after drilling by wagon drills. The stone is then broken to a suitable size for the primary crushers, and is loaded by a 1¼ cu. yd. Ruston-Bucyrus face shovel into 12-tons end-tipping lorries for transport to the works. Air for the wagon drills and for the drills for pop-blasting is supplied by portable diesel-driven air-compressors.

CLAY.—Clay is obtained from near the Malawa river, five miles from the works, and is dug by a ¾ cu. yd. Ruston-Bucyrus drag-line excavator which loads directly into 3-tons end-tipping lorries for transport to the works.

GYPSUM.—Gypsum is imported and is unloaded by hand from railway trucks either into the store or to an open stockpile.

Handling Raw Materials.

LIMESTONE.—The limestone handling plant is designed so that stone in which the P_2O_5 content is not excessive can be sent directly to the works for the manufacture of cement. Limestone containing an excess of P_2O_5, however, is burnt and hydrated before it is used for cement manufacture. The plant is arranged so that cement can be made directly from limestone and clay, or limestone, hydrated lime, and clay, or hydrated lime and clay.

At the works, limestone is discharged from end-tipping lorries into either of two reinforced concrete hoppers, each of 18 tons capacity, at ground level, and if desired the stone can be discharged into these hoppers from railway trucks. From these hoppers the stone is conveyed to the primary crushers by two 36 in. wide steel-plate apron-feeders at 25-ft. centres; each feeder is driven through worm reduction-gear by a 10-h.p. motor operating at 960 r.p.m.

The two primary jaw-crushers have a jaw opening 36 in. by 24 in., and each is capable of producing 50 tons per hour of stone reduced to 4 in. cubes and smaller. Each crusher is rope-driven by an 80-h.p. motor at 720 r.p.m. The stone from these machines is discharged through steel chutes on to a 36-in. wide inclined belt-conveyor at 170-ft. 2½-in. centres; this conveyor has a capacity of 100 tons per

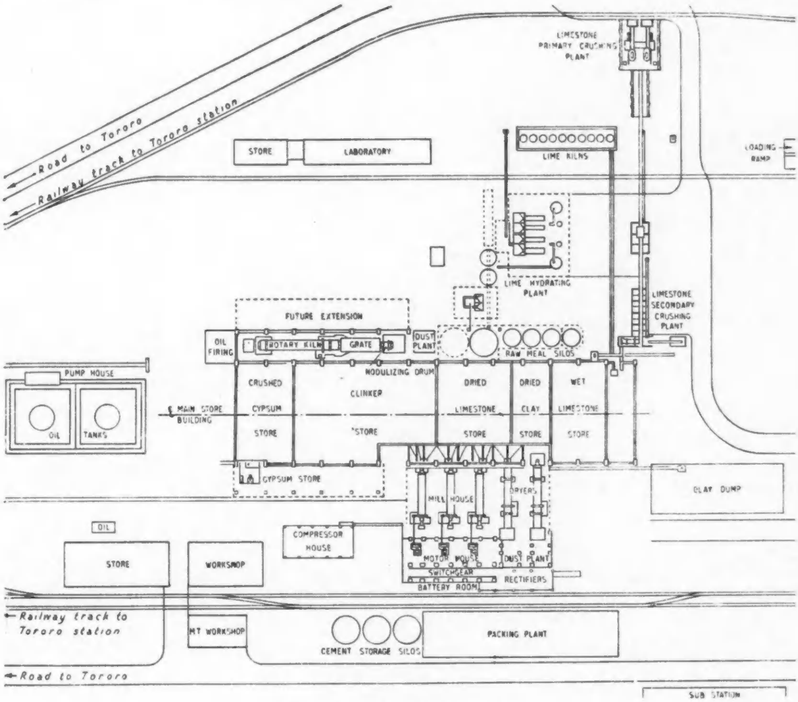


Fig. 1—Plan of Works.

hour, and is driven by a 20-h.p. motor through a reduction-gear coupled to the head-shaft. From the conveyor the stone passes over a vibrating rod-screen to remove soil and dust which fall into a steel bunker below; the height of the bunker allows the discharge of dust into lorries for transport to a tip. The discharge from the rod-screen is on to a picking belt-conveyor 42 in. wide by 12 ft. long, which is rope-driven by a 3-h.p. motor at 950 r.p.m. The product from the picking-belt is conveyed by a belt-conveyor 30 in. wide by 120 ft. long and discharged by a travelling tripper into one or other of eight bunkers, or alternatively directly to a rotary screen or to bunkers over the secondary crushers. This conveyor is rope-driven by a 10-h.p. motor at 700 r.p.m.

At this point the stone is analysed to determine whether it is suitable for producing cement or if it requires burning and hydrating to remove the apatite. Stone which does not require further treatment is discharged from the bunkers through manually operated valves and chutes on to a 24-in. wide belt-conveyor which discharges into a two-compartment steel bunker; the lower part of the bunker is hoppered and has a flanged opening through which the stone falls on to two 24-in. wide shaking-tray feeders, each driven by a variable-speed geared motor of 1·6 h.p. at 1,400 r.p.m. Each feeder discharges to a 26-in. by 20-in.

swing-hammer mill, which reduces the stone from 4 in. to a size suitable for the raw mills at the rate of 25 tons per hour. Each hammer-mill is rope-driven by a 50-h.p. motor at 1,440 r.p.m. The product from these mills is taken by an inclined troughed belt-conveyor 24-in. wide by 87 ft. 6in. long to a vertical bucket-elevator 20 in. wide at 45-ft. centres which discharges the stone into the main store building from where it is taken to the drying section of the plant. The 24-in. crushed stone conveyor is driven through a worm reduction-gear by a $7\frac{1}{2}$-h.p. motor at 1,450 r.p.m., and the 20-in. elevator is driven through a worm reduction-gear by an 8-h.p. motor at 1,440 r.p.m.

Stone which requires treatment for the removal of apatite is discharged from the eight bunkers in the same manner as the stone which does not need treatment, but instead of being conveyed to the secondary crushers it is by-passed through a bifurcated chute from the conveyor feeding the secondary-crusher bunker into a rotary screen 5 ft. diameter by 15 ft. long with $1\frac{1}{2}$-in. diameter perforations; material passing the screen is collected in a bunker below and subsequently taken away by lorry to tip; however, provision is made whereby this material can be returned into the process if necessary. Oversize material is discharged from the screen on to a belt-conveyor 20-in. wide by 27 ft. long which takes it into the main store building. The rotary screen is rope-driven by a 10-h.p. motor at 1,420 r.p.m., and the belt-conveyor is rope-driven by a 3-h.p. motor at 950 r.p.m.

Lime Burning.

The over-size stone with a high apatite content is taken from the main store building through a hopper at ground-level by an apron-feeder 36 in. wide by 72 in. long, which is rope-driven by a 3-h.p. motor at 710 r.p.m. and discharges on to an inclined belt-conveyor 20 in. wide by 248 ft. 3 in. long which elevates the stone from ground level to a height of 55 ft. for feeding to the lime kilns; this conveyor has a capacity of 20 tons per hour and is rope-driven by a $7\frac{1}{2}$-h.p. motor at 750 r.p.m.

THE KILNS.—The lime-burning plant comprises ten induced-draught vertical kilns with mechanical feed and discharge for stone and lime, and with arrangements for feeding fuel in the form of wood-chips. The kilns are spaced at 10-ft. centres; they have an internal diameter of 5 ft. and a total depth of preheating, burning, and cooling zones of 24 ft. 9 in. Two down-draught fire-boxes for burning wood-chips are placed one on each side of the kilns. The kilns are supported on a reinforced concrete structure which is extended to carry the feeding arrangements for the stone and wood-chips. On top of each kiln is an exhauster-fan for inducing air to pass through the kiln; each fan is rope-driven by a 15-h.p. motor. The gases pass through a chimney to the atmosphere; arrangements are, however, made in the exhaust-pipe to by-pass the fan so that the kiln can operate on natural draught and discharge gases directly to the atmosphere.

HANDLING MATERIALS.—The stone from the 20-in. inclined belt-conveyor discharges on to a tipping tray-conveyor 15 in. wide which can tip to either of the kiln feed-hoppers; this conveyor is driven by a $12\frac{1}{4}$-h.p. motor at 1,460 r.p.m. through worm reduction-gear coupled to the head-shaft. The stone then falls into steel hoppers each with a capacity of $4\frac{1}{2}$ tons. From these hoppers the stone

is discharged through manually operated valves into rotary-bucket wheel-feeders having a capacity of one-third of a ton; these feeders are arranged for manual operation but they can be arranged for electrical drive if necessary. Since each kiln has an input of 30 cwt. per hour, it is necessary to fill and empty the rotary-bucket wheel-feeders about once every thirteen minutes only.

WOOD FUEL.—The kilns require 70 tons of wood fuel per day. Timber, in the form of logs, is brought from the Government forest reserve at West Bugwe, about nine miles from the factory, by lorries on a road constructed for this purpose. At the works the logs are stored in piles from which they are taken to the hogging machine by a conveyor 100 ft. long which discharges on to another inclined conveyor 27 ft. long; each conveyor has a speed of 2.18 ft. per second and is chain-driven from the head-shaft by a 5-h.p. geared motor having a speed of 75 r.p.m. From the head of the conveyor the logs fall down a steel chute into a hogging machine which reduces them to chips at the rate of ten tons per hour; this machine is rope-driven at a speed of 350 r.p.m. by two 100-h.p. motors at 900 r.p.m. From the base of the hogging machine the chips fall on to an inclined belt-conveyor 18 in. wide by 35 ft. long, rope-driven by a 3-h.p. motor at 950 r.p.m. The chips are discharged on to an inclined belt-type loader 18 in. wide at 60-ft. centres mounted on swivel wheels which permits stock-piling over a large area in the open and is rope-driven by a 5-h.p. motor at 710 r.p.m. The chips are taken from the stockpile by automatic feeders below the floor of the hoppers, which discharge on to a horizontal belt-conveyor 16 in. wide by 80 ft. long, which is rope-driven by a 3-h.p. motor at 950 r.p.m. This conveyor delivers the chips to a 15-in. wide vertical bucket-elevator at 50-ft. centres, which takes them to two hoppers, one on each side of the lime kilns at firing-floor level; this elevator is rope-driven by a 7½-h.p. motor at 700 r.p.m. From these hoppers the chips are delivered into the fire-boxes of the kilns.

HANDLING THE LIME.—Burnt lime from each kiln is discharged through a cooling-cone on to a 24-in. wide reciprocating tray-feeder operating at 16 strokes per minute, the stroke being adjustable; each feeder is driven by a 2-h.p. geared motor at 960/16 r.p.m. connected directly to the driving shaft. From the feeders the lime is discharged on to an 18-in. wide tray-conveyor which takes it to transverse belt-conveyors to supply the hydrating plant. The trays of the conveyor travel at 20 ft. per minute, and have a capacity of 10 tons per hour; the conveyor is driven by a 12.5-h.p. motor at 1,460 r.p.m. with a speed-reducer connected directly to the driving shaft. The discharge from the reciprocating feeder is arranged so that under-burnt lime can be transferred into decauville trucks for disposal.

The lime from the transverse tray-conveyor is discharged on to two 24-in. wide troughed belt-conveyors, one horizontal in a trench below ground and the other at an inclination suitable for feeding the crushers of the dehydrating plant; the horizontal conveyor is chain-driven by a geared motor of 3 h.p. at 940/61 r.p.m., while the inclined conveyor is driven in a similar manner by a 5-h.p. geared motor at 940/61 r.p.m.

Lime Hydration Plant.

The hydrating plant consists of two units each comprising two hydrators and has a total capacity of 16 tons of lime-hydrate per hour. Burnt lime is received

from the kilns by a belt-conveyor which discharges through a bifurcated chute into two Sturtevant No. $1\frac{1}{2}$ rotary crushers which reduce it to $\frac{3}{4}$-in. size and under for feeding to the hydrators; these conveyors are rope-driven by 20-h.p. motors at 975 r.p.m. From each crusher the lime falls into the boot of a totally-enclosed 12-in. bucket-elevator, which lifts it to a height of about 50 ft., where it is discharged through a steel chute into a totally-enclosed steel storage-bunker; each elevator is driven at the head through gears and ropes by a $7\frac{1}{2}$-h.p. motor at 725 r.p.m. The storage bunkers have a capacity of about 100 tons, and have transmitters for giving visible and audible warnings of high and low level of lime. The lower part of the bunkers is formed into two hoppered sections with a flange to which a constant-weight feeder is attached to control the supply to the hydrators.

At this stage water passes through a control valve and a flow indicator and the lime and water are mixed before proceeding to the hydrators, which are of the Sturtevant-Knibbs continuous type each having a capacity of 4 tons per hour; the quantity of water added is such as to ensure that the lime leaves the hydrator as a dry powder. Each hydrator is driven by a 15-h.p. motor at 725 r.p.m. through an enclosed worm-reduction gear coupled to the driving shaft, and is complete with a washer preheating equipment which is rope-driven by a 5-h.p. motor at 1,440 r.p.m.

The hydrate from each pair of hydrators is discharged into the boot of a 14-in. wide totally-enclosed vertical bucket-elevator at 48 ft. centres driven by a 10-h.p. motor at 725 r.p.m. through ropes to gears on the head shaft; from the elevator the hydrate is conveyed by a 15-in. diameter screw-conveyor to a 14-ft. diameter Sturtevant air-separator; the screw-conveyor is chain-driven from the head-shaft of the elevator, and the separator is rope-driven by a 25-h.p. vertical-spindle motor at 725 r.p.m. The separator removes the coarse particles; the finished product leaves the air separator at a central outlet in the base through a rotary valve chain-driven by a 2-h.p. geared motor at 1,420/123 r.p.m., and passes into an air-slide conveyor for transference to the finished-hydrate storage silos.

The coarse particles from the 14-ft. separator are discharged into a 12-in. diameter screw-conveyor and taken to a 7-ft. diameter separator for further separation; the screw-conveyor is chain-driven by a 3-h.p. geared motor at 1,440/125 r.p.m. and the tailings separator is rope-driven by an 8-h.p. vertical-spindle motor at 970 r.p.m. The finished product leaves this separator through a flanged outlet in the lower part of the machine, to which is fitted a rotary valve chain-driven by a 2-h.p. geared motor at 1,420/123 r.p.m. This product combines in the air-slide conveyor with the hydrate from the 14-ft. diameter separator. The tailings from the 7-ft. diameter separator are discharged into a 12-in. bucket-elevator at 50-ft. centres which is rope-driven by a 6-h.p. motor at 720 r.p.m. From the elevator the tailings discharge into a hopper from which they are delivered for agricultural purposes.

The air-slide conveyor collecting the finished hydrate is 6-in. wide and is supplied with air from a high-pressure fan which is rope-driven by an 8-h.p.

motor at 1,440 r.p.m. In order to prevent restriction of the porosity of the slide, loose dust is continuously drawn from the top by a No. 1 Monogram fan, which is rope-driven by a 1-h.p. motor at 1,440 r.p.m. The dust is passed through a collecting and washing plant, the sludge from which is returned to the hydrators. From the air-slide conveyor the finished hydrate is discharged into a 16-in. vertical bucket-elevator, fitted at the discharge with a bifurcated chute for discharging to either of two silos; the elevator is rope-driven at the head-shaft through gears by a 10-h.p. motor at 720 r.p.m.

The hydrating plant is in a steel-framed building 72 ft. long by 51 ft. 9 in. wide by 40 ft. high to the eaves, roofed with protected metal sheeting.

The hydrate is stored in two reinforced concrete silos each 14 ft. 9 in. inside diameter by 50 ft. high; the lower part is conical and has a 4 ft. outlet with a steel connecting-piece arranged to suit the screw extractor. To assist in emptying the silos and to maintain the hydrate in a semi-fluid state, aeration pads are fitted at the outlets. Hydrate from the silos is conveyed to the blending plant (described later), and provision is made to pass it to a bagging plant for disposal for building purposes.

MANUFACTURE OF CEMENT.

Main Stores Building.

The main stores building in which dry clay, wet and dry limestone, cement clinker, and gypsum are stored is a reinforced concrete structure 420 ft. long, 98 ft. 5 in. wide between the crane rails, 56 ft. high to the crane rail, and 66 ft. 4 in. high to the eaves. A 10-tons overhead electric crane is fitted with a 5-tons grab-bucket for distribution of material inside the building, and also for feeding wet limestone to the dryer, dry limestone and clay to the raw mill, and cement clinker and gypsum to the cement mill. The crane has four motors: the motor for raising and lowering the grab, at a speed of 160 ft. per minute, is of 140-h.p. at 600 r.p.m.; the motor for opening the grab is of 60-h.p. at 600 r.p.m.; a 13½-h.p. motor at 800 r.p.m. moves the grab across the building at a speed of 200 ft. per minute; and a 43½-h.p. motor at 810 r.p.m. moves the crane along the building at a speed of 400 ft. per minute. Limit-switches are fitted for both transverse and longitudinal travel, and the controls for all the motors are in the driver's cab which travels with the crane.

On one side of this building is a lean-to over the kiln, and on the opposite side is a building for the raw and cement mills. Inside the store and adjacent to the mill house are reinforced concrete bunkers for raw materials and cement clinker. Traversing the store from the mill-house to the kiln-house are two reinforced concrete tunnels, to accommodate the pipe-line from the "Cera" pumps from the raw mill to the raw-meal silos, and also cables and water mains. The roof of the stores building is covered with protected steel sheeting and the sides from the crane-rails to the eaves are filled in with the same material. Around the building is a 12-ft. high reinforced concrete retaining wall. The space between the top of one retaining wall and the under-side of the crane girder is open except

between the store and the mill house and the kiln building, where it is walled to prevent dust entering these buildings.

Drying the Clay.

On arrival at the works the clay is dumped into a shed which is roofed but has open sides. Here the clay undergoes a certain amount of air drying, and is then taken by Decauville trucks to a hopper at floor level feeding into rolls which reduce the clay to about 1-in. pieces. The clay-rolls are rope-driven by a 13.5-h.p. motor at 960 r.p.m. Under the rolls is a 20-in. wide inclined belt-coneyor 170 ft. long driven through worm reduction-gear by a 10-h.p. motor at 1,440 r.p.m. The clay is discharged from this conveyor into a single-tube rotary-dryer 7 ft. 6 in. diameter by 66 ft. long set at an inclination of 7 per cent. The dryer rotates on two steel tyres supported on cast-steel rollers mounted on steel bed-plates. A spur-ring bolted to the shell engages with a steel pinion mounted on a bedplate, and the end of the pinion shaft is fitted with a "Bibby" type flexible coupling connected to a totally-enclosed spur gear; the dryer is driven through a flexible coupling by a 30/15-h.p. variable-speed motor at 970/460 r.p.m. The bedplate adjacent to the driving gear is fitted with a double set of steel rollers for resisting axial thrust, and allowance is made for expansion when the dryer is working.

The inlet end of the dryer has a cast-iron conical head which has quick-acting helical blades to propel the clay into the dryer; this end has also a reverse conical flange, to prevent back spillage. On the conical head is a floating-type air-sealing ring the outer half of which is fixed to the brickwork at the end of the dryer, where a sealing-ring prevents cold air entering the dryer. The dryer is lined inside with firebrick and has lifters which cascade the clay through the hot gases. The ends rotate in brick chambers. The inlet is in the form of a combustion chamber containing the fuel-oil burning apparatus, dampers, and regulators; temperature-gauges and draught-gauges are on a panel from which the firing conditions are controlled. The outlet is in the form of a box with a hoppered bottom into which the dried clay is collected and discharged through a chute to an inclined tray-conveyor; an air-sealing ring is fixed to the outlet. The chambers at each end are built of brickwork, the inner face being lined with firebricks with an alumina content of about 40 per cent. and the outer casing is of ordinary quality red brick; stays and tie-rods ensure the rigidity of the structures.

The brick chamber at the outlet end has an opening 55 in. by 40 in. for the discharge of exhaust gases; the exhaust fan has an impeller of 60 in. diameter and is mounted on a steel shaft running in water-cooled bearings lined with white metal. The shaft is rope-driven by a 55-h.p. motor at 970 r.p.m. The discharge duct from the fan is bifurcated, and at the end of each leg is a cowl connected to an electrical dust-precipitator.

Dust Precipitators

The dust-precipitating plant is in two units both of which are normally in operation, but if necessary the exhaust gases can be handled by one unit whilst the other

is undergoing repair. The outer casing housing the preciptation cells and control gear is of reinforced concrete. In each precipitator there are six units each of 41 cells; in the centre of each cell is suspended a stainless-steel wire kept taut by counterweights, and to each wire is connected high-potential voltage of constant negative charge. The resulting potential gradient thus repels the particles of dust outwardly from the charged wire and precipitates them on to the walls of the cells. The electric vibrators are controlled through cyclic relays which impart vibrations to the steel cells and thus cause the adhering dust to fall into a hopper below. For each unit a single-phase transformer increases the standard 415 voltage to 60,000 volts a.c., and a rotating half-wave rectifier supplies the unidirectional current to the wires; the rectifier has an output of 20 k.v.a. and is in the sub-station

Fig. 2.—Clay Dryer and Conveyor.

The lower part of the precipitation chamber is a double hopper-bottom with an outlet flange to which are connected two spiral conveyors of 10 in. diameter which are chain-driven by a 3-h.p. geared motor at 970/63 r.p.m. The outlets of the spiral conveyors are connected by steel chutes which deliver the dust into a rotary valve and air seal; the valve is chain-driven by a 1·5-h.p. geared motor at 970/63 r.p.m. From the valve the dust is discharged, with the clay from the dryer, on to an inclined bucket-elevator, with 12-in. wide buckets, which elevates the clay about 30 ft. into the main stores building; the elevator is chain-driven by a 10-h.p. geared motor at 970/27·5 r.p.m.

Drying the Limestone.

Wet limestone is dried in a similar manner to the clay, but in this case the stone is taken from the store by the grab-crane and dumped into an overhead reinforced concrete bin with a central partition forming two compartments each 17 ft. 6 in. by 14 ft. at the top and having a capacity of 160 tons. The lower part of the bin is hopper-shaped with a rectangular outlet fitted with a telescopic steel sleeve for regulating the amount of stone delivered to the table-feeder. Arrangements are made for visual observation of the material delivered to the feeders, and for the removal of foreign matter. A table-feeder of 1 metre diameter is situated under each compartment of the bin for regulating the amount of stone fed into the dryer; these feeders are totally enclosed, and have an inspection-door and an adjustable plough for varying the amount of stone fed to the dryer. Each table-feeder is driven by a 2·5-h.p. geared motor at 950/33·5 r.p.m. direct-coupled to the shaft. The drying department, including the dust-precipitation plant and the tray-conveyor, is a duplicate of the clay-drying department.

Grinding Raw Meal and Cement Clinker.

In the mill house for grinding the raw meal and cement clinker are three mills of identical size and arrangement. The product from each mill discharges into a "Cera" pump which can deliver by pipeline to the raw meal silos or the cement silos; thus any mill can be used for grinding either raw meal or cement clinker. Over each mill, and projecting into the main store building, are three bunkers which are fed by the overhead travelling grab crane in the stores building. Each bunker is divided into three compartments; two measuring about 17 ft. 6 in. by 10 ft. at the top have a capacity of 100 tons of raw limestone or cement clinker and the third compartment measuring 17 ft. 6 in. by 6 ft. 3 in. at the top has a capacity of about 35 tons of clay or gypsum. The lower part of each compartment is hoppered and has a rectangular opening with a valve and telescopic sleeve for regulating the amount of material delivered to the table-feeders.

Similar arrangements for visual inspection of the feed and for removal of foreign matter are made as for the bunkers feeding the raw-material dryers. Two 1,000-mm. diameter table-feeders for stone and one 750-mm. diameter table-feeder for clay regulate the proportions of materials to the raw mill; similar arrangements are installed for regulating the proportion of clinker and gypsum to the cement mill. The 1,000-mm. feeders are shaft-driven by a 2·5-h.p. geared motor at 950/33·5 r.p.m.; the 750-mm. feeder is driven by a 2·5-h.p. geared motor at 970/6·3 r.p.m. All the feeders are totally enclosed, with inspection doors in the covers and ploughs for the adjustment of the feed. Discharge from the three feeders is into a common chute at the inlet end of the mill, where arrangements are made for measuring the rate of feed to the mill.

The mills are 7 ft. 3 in. diameter by 42 ft. 9 in. long and are divided into three compartments. The first compartment is lined with chrome-steel stepped plates and charged with 12½ tons of chrome-steel forged balls 3½ in. to 2½ in. diameter; the second compartment is also lined with steel stepped plates, and is charged with 7½ tons of chrome-steel forged balls 2 in. to 1¼ in. diameter; the third

compartment is lined with Silex blocks and charged with 22 tons of 1 in. by 1 in. and $\frac{5}{8}$ in. by $\frac{5}{8}$ in. Cylpebs. Between the first two compartments is a screen, and the oversize material is returned to the first chamber for further grinding. Fitted to the diaphragm between the second and third compartments is an arrangement for admitting air to ventilate the third compartment. At each end of the shell is a cast-steel head supported in oil-lubricated water-cooled bearings lined with white metal. In the inlet end is a drum feeder and a helix for propelling the material

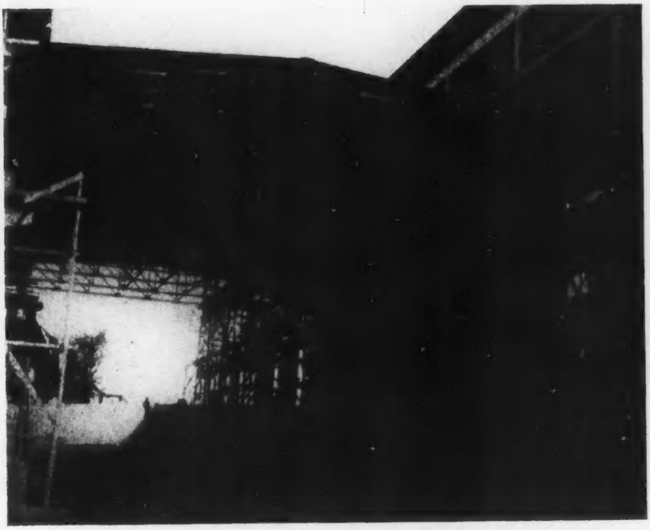


Fig. 3.—Dryer and Mill House.

from the table-feeders into the first compartment. In the outlet end is a helix for propelling the material from the discharge diaphragm to a nib screen; the fines from this screen pass to the "Cera" pump for transport to either the raw meal or the cement silos. The grit from the nib screen is discharged through an outlet on the dust-cover to a receptacle. The outlet head has a machined flange to which the driving wheel is keyed; this wheel is 15 ft. diameter and has 144 teeth engaging with the driving-pinion which is keyed on to a forged-steel shaft $7\frac{1}{2}$ in. diameter mounted on four bearings lined with gunmetal; keyed to one end of the shaft is a half-flexible coupling, the other half of the coupling being keyed on to a totally-enclosed gear which reduces the speed of the 675-h.p. motor from 860 r.p.m. to 144 r.p.m.

On the discharge hood of each mill is connected the piping to a suction dust-filter which keeps the house free from dust. These filters have 68 fabric filter-stockings each 8 in. diameter by 10 ft. long, with arrangements for automatic

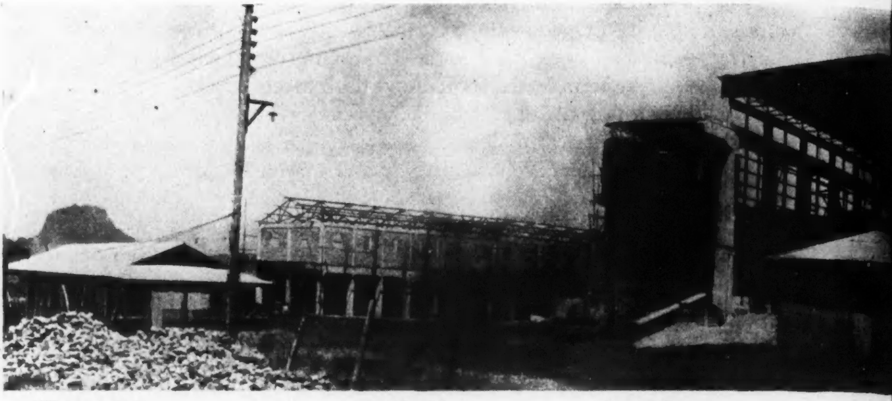

Hill from which limestone is obtained. Packing Plant. Raw and Cement Mill House. Stores (Ki

Fig. 4.—Vie

shaking through a geared motor of 1·5 h.p. at 970/74 r.p.m.; the dust in the filter is collected in the hoppered bottom of the casing, from which it is taken by a helical conveyor to the hopper feeding the "Cera" pump; the helical conveyor is driven by a 2-h.p. geared motor at 970/74 r.p.m.

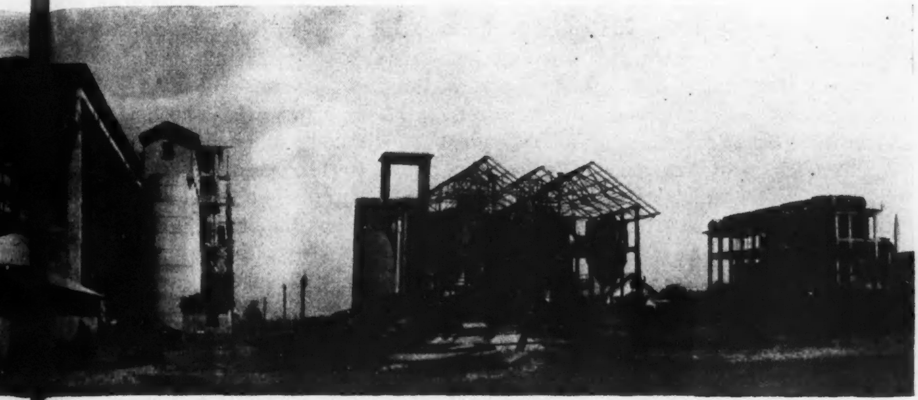
The fan for drawing the dust-laden air through the filter has a suction of 28 in. diameter and an impeller of 48 in. diameter; the impeller shaft is mounted in two ball bearings, and one end is coupled to a 25-h.p. motor at 970 r.p.m. The filters are on a floor which forms the roof of the mill-motor room, which is 24 ft. wide and in which is a 5-tons hand-propelled travelling crane for maintenance purposes.

Raw-Meal Silos.

From the Cera pump the raw meal is transported pneumatically through a 90-mm. diameter pipe to either of four reinforced concrete raw-meal silos, which are 14 ft. 9 in. diameter by 53 ft. high and have a capacity of 250 tons each. The base of the silo, which has a 10-deg. slope, is fitted with aeration plates which maintain the material in a quasi-liquid state suitable for discharge through a valve into a 10-in. wide air-slide conveyor. There is a filter at the base of the silos where air from the main air-compressor is filtered before it is taken to the aeration plates, thus ensuring that only clean and dry air is used. From the air-slide conveyor the material can be re-circulated into any of the four silos, to the blended-meal silo, or transported to the blending plant. For re-circulation, the material is taken to the top of the silos by a 16-in. wide bucket-elevator which discharges into a 10-in. wide air-slide conveyor from which it is discharged to the silos as required. Air for the air-slide conveyors is supplied by centrifugal fans driven by 2-h.p. motors at 2,760 r.p.m.; the elevator is driven by a 10-h.p. motor at 1,400/120 r.p.m. through a gear-wheel keyed to the head-shaft.

Blending Plant.

From the air-slide conveyor the raw meal is discharged into a 15-in. helical conveyor which is chain-driven through a reduction gear by a 5-h.p. motor at



Raw Meal Silos. Lime Hydrating Plant Lime Kilns.

960 r.p.m. The raw meal is thus conveyed to the boot of a 14-in. wide steel-cased vertical bucket-elevator at 56 ft. 6 in. centres, which discharges into one compartment of a double storage bunker; in the other compartment of this bunker is stored hydrated lime which has been conveyed from the hydrating plant. Extraction of the hydrated lime is by a 6-in. diameter screw-feeder coupled to a variable-speed gear-box driven by a 3-h.p. motor at 960 r.p.m. The discharge from these feeders is into a 15-in. diameter screw-conveyor 44 ft. long chain-driven through a reduction gear by a 5-h.p. motor at 960 r.p.m. From this conveyor the lime is elevated into the other compartment of the double storage-hopper by a 14-in. wide vertical bucket-elevator at 56 ft. 6 in. centres; this is a duplicate of the elevator handling the raw meal and is rope-driven by an 8-h.p. motor at 720 r.p.m.

The double-compartment bunker is of steel plate and totally enclosed. The lower part of each compartment is hoppered and has an outlet to which is connected the screw-feeding device of automatic weighing machines, one for weighing lime and the other for weighing raw meal. Each weighing machine is chain-driven through a reduction gear by a 2-h.p. motor.

The discharge from the weighing machines is to a No. 40 batch-blender, in which the raw meal and lime are proportioned and mixed. This machine is generally similar to a concrete mixing machine, being rotated by a chain fixed around the drum; the sprocket for driving the chain is keyed to the shaft of a worm reduction-gear. On the top of the blender is a 10-h.p. vertical-spindle motor running at 1,440 r.p.m. From the blender the raw meal is taken in a 15-in. diameter screw-conveyor 38 ft. long to the boot of a 16-in. totally-enclosed bucket-elevator 56 ft. 6 in. high which takes the meal to the top of the silo and discharges on to a 15-in. conveyor which distributes the material into the blended-meal silos. All these machine are connected to a dust-collecting plant

of the filter-stocking type, having six 15-in. diameter stockings 13 ft. 6 in. long with arrangements for hand shaking. The fan which delivers air to the filter is rope-driven by a 5-h.p. motor at 1,440 r.p.m. Compressed air is supplied to the porous aeration pads fitted to the hydrate silos from a water-cooled air-compressor which is rope-driven by a 5-h.p. motor at 720 r.p.m. A desk-type panel on the operating platform of the blender contains the controls for the whole of the blending plant; the panel includes push-button starters with indicating lights for all motors, alarm switches, centrifugal switches, radiovisor indicators for bunker high and low levels, switches for electric vibrators for bunkers, and indicators showing the flow of material through the plant. The blending plant is in a steel-framed structure 32 ft. long by 24 ft. wide by 53 ft. high to eaves, and is covered with protected steel sheeting.

The blended-meal silo is of reinforced concrete 26 ft. 3 in. diameter by 53 ft. high and has a capacity of 750 tons. On top of the silo is a dust-collecting plant connected to the pipes of the raw-meal silos and also to the "breather" of the blended-meal silo. The dust-collector is of the circular automatic-shaking type and has 48 fabric filter-stockings 6 in. diameter by 5 ft. long in four compartments, each compartment being vibrated in sequence by a 2-h.p. geared motor at 970/8·3 r.p.m. The lower part of the casing is in the form of a hopper from which the dust is returned to the silo through a flap-type valve. The bottom of the silo is in the form of a tunnel in the shape of an inverted vee. At the base of the tunnel are six outlets, three on each side, to which are attached a steel frame with screw-down shut-off valves. To this frame is fixed a steel casing, the outer end of which is connected to the floor of the tunnel and is over a trough which forms the casing for the screw-conveyors. Inside the casing is a semi-rotary undercut valve which regulates the discharge from the silo. Inside the base of the silo, and adjacent to each outlet, are porous plates to which compressed air is supplied.

Feeding the Kiln.

Two 16-in. diameter helical conveyors, each 106 ft. 6 in. long, transfer the blended meal from the silo to the kiln. At the feed-end of the conveyor the helix is in a trough in the base of the concrete silo, the top of the trough being covered with steel-grid flooring; for the remainder of the trough the helix is in a steel casing. Attached to the cover-plate is an inlet for dust from the precipitation plant. At the outlet of these conveyors the meal is discharged into a transverse 16-in. diameter screw-conveyor 12 ft. long which discharges through a bifurcated steel chute into the boots of two vertical bucket-elevators. Each of the longer screw-conveyors is coupled to a totally-enclosed worm reduction-gear driven by a 10-h.p. motor at 720/45 r.p.m., the transverse conveyor is driven in a similar manner by a 5-h.p. motor at 710 r.p.m. Two 12-in. wide totally-enclosed vertical bucket-elevators at 76 ft. 6 in. centres elevate the meal to the top of the granulator building. These elevators are duplicated in case of breakdown, and have pressed-steel buckets joined by links to two strands of cable-chain. Each elevator is driven by spur-wheel gear and a pinion keyed to the shaft of a totally-enclosed geared motor of 8 h.p. at 1,400/120 r.p.m. The

elevators are connected at the top by steel chutes which discharge into a screening screw-conveyor. Valves in the discharge chute enable the screening conveyor to be by-passed and the meal discharged into a reinforced concrete storage bunker beneath the granulating drum. The lower portion of this bunker is hoppered, and to the outlet is connected a steel frame with a shut-off valve. Connected to the frame is a double 6-in. diameter screw-extractor, chain-driven by a 5-h.p. geared motor at 1,400/120 r.p.m. The discharge from the extractor is by a steel chute into either of the two 12-in. wide elevators previously described. With this arrangement the kiln can be kept in operation should the extraction screws from the silo be stopped.

The screen-conveyor is 22-in. diameter and removes any large particles in the meal and discharges them through a chute at the outlet end into the feed hopper of the Lepol grate. Should the screen-conveyor be over-fed by the elevators, reverse helical conveyors on the outside of the screen propel the surplus material into the chutes feeding the bunker. The screen-conveyor is direct-coupled to a totally-enclosed geared 6-h.p. motor at 970/39 r.p.m. The product from the screen-conveyor is collected into a steel hopper with a flanged outlet connected to a rotary feeder which regulates the supply to the granulating drum; the feeder is chain-driven by a 2-h.p. variable-speed motor at 1,200/400 to 40/13 r.p.m.

The granulating drum is 7-ft. diameter by 13 ft. long and is at an inclination of 4 per cent. On the drum are two steel tyres, each rotating on two steel rollers supported on a steel bedplate. The drum is turned by a spur gear engaging with a pinion keyed to a shaft mounted in bearings lined with white metal; one end of the shaft is coupled to a totally-enclosed spur gear and is driven by a 34/21-h.p. variable-speed motor at 1,000/650 r.p.m. Steel structures at the inlet and outlet ends of the granulator carry the spring-loaded feed and discharge cover-plate. These structures also support the device for cleaning the inside of the shell; this device has adjustable blades and is operated by a racking screw from a hand-operated control. Water is fed into the granulating drum through small spray holes in pipes; gun-metal valves regulate the supply from a constant-pressure feed-tank on the top floor.

The granulating equipment is in a reinforced concrete building 39 ft. 6 in. long by 35 ft. 6 in. wide by 15 ft. high, with a reinforced concrete floor 62 ft. 3 in. above ground for supporting the sieving conveyor and the heads of the elevators. A concrete floor 52 ft. 9 in. above ground supports the driving gear for the rotary feeder, and at a height of 42 ft. 3 in. a floor, formed partly by the roof of the granulating bunker, carries the granulator and driving gear. The sides of the building above a height of 42 ft. 3 in. are enclosed between columns by concrete blocks 6 in. thick.

The Moving-Grate.

The meal in the form of nodules is discharged from the granulator into the feed-hopper of the kiln. The moving-grate is 7 ft. 6 in. wide and 24 ft. 9 in. long and travels at 100 ft. per hour. On the grate the nodules are carried in a layer between 6 in. and 8 in. deep, and at the discharge end are transferred by a chute into the kiln. The grate is in a casing of steel frame and brick; the upper

part of the casing is divided by an adjustable damper into two parts, the first of which is the drying chamber, where the nodules are dried, and the second the heating chamber, from which the nodules are discharged into the kiln.

Hot gases from the kiln enter the grate chamber at the outlet end at a temperature of about 950 deg. C., and travel over and through the nodules. In doing so the temperature of the gases falls to about 150 deg. C., thus desiccating and to a large extent decarbonating the material. On the roof of the grate-casing are an auxiliary stack and mixer having dampers and regulators so that the gases can be regulated to the required temperature for the drying chamber. Access and inspection doors are fitted to the casing for cleaning and maintenance purposes, and for observation of working conditions. The grate is driven by a 12·6-h.p. variable-speed motor at 1,000/500 r.p.m. through two sets of totally-enclosed reduction gears, a spur gear reducing the speed from 1,000/500 to 20/10 r.p.m. and a worm-gear further reducing the speed to 0·4/0·2 r.p.m.

The lower part of the casing is hoppered and flanged at the outlet, from which a conveyor removes the dust to the boot of the two elevators feeding the granulating plant. The conveyor is of the scraper type having a 6 in. wide steel-link chain and is supported in a totally-enclosed steel casing 8 in. wide; an automatic tension device for the chain is provided by a wire rope and counterweights, and the conveyor is chain-driven by a 6-h.p. geared motor at 970/31 r.p.m. In the lower part of the casing is an opening, to which the suction-duct of an exhaust-fan is connected, for the outlet of gases. This fan has an impeller of 57 in. diameter on a steel shaft and revolves in two 4-in. diameter water-cooled bearings lined with white metal. On one end of the shaft is keyed a coupling from an 80/40-h.p. variable-speed motor at 1,000/500 r.p.m. The discharge duct from the fan is bifurcated and terminates with a cowl connected to the reinforced concrete casing of an electrical dust-precipitation plant. This plant is in two sections; generally it is as described for the dryer dust-precipitation unit, but it has 12 units each of 33 cells.

The lower part of each section of the dust-precipitation plant has two collecting-hoppers into which the dust falls from the cells; the base of these hoppers has a flanged casing to which screw-conveyors are attached. Each of of the four conveyors is driven through bevel-gears by a 3-h.p. geared motor at 970/63 r.p.m. The dust from these conveyors is transferred to a transverse screw-conveyor which discharges into the screw-conveyors handling the meal from the silo to the kiln; this conveyor is also driven through bevel gears by a 3-h.p. motor at 970/63 r.p.m.

The Kiln.

The kiln is 8 ft. 8 in. diameter by 88 ft. 6 in. long. It is set at an inclination of 3·5 per cent. and is carried on two cast-steel tyres 10 ft. 2 in. diameter by 15 in. wide supported on cast-steel rollers 3 ft. 7½ in. diameter by 17 in. wide shrunk on to forged-steel shafts and water-cooled oil-lubricated bearings, lined with white metal, on rolled-steel fabricated bedplates. On the bedplate adjacent to the driving gear are two rollers for resisting the axial thrust of the kiln. Sealing rings of the floating type at the inlet and outlet ends of the kiln prevent leakage of air.

Bolted to the shell of the kiln is a cast-steel spur-wheel 13 ft. 8 in. diameter by 10¼ in. wide having 130 teeth at 4 in. pitch which engage with a cast-steel pinion 2 ft. 7½ in. diameter by 12 in. wide having 25 teeth; the pinion is keyed to a forged-steel shaft revolving in grease-lubricated bearings lined with gunmetal and carried on a rolled-steel fabricated bedplate. One end of the pinion-shaft is fitted with a half-flexible coupling which engages with a half-coupling connected to a totally-enclosed spur reduction-gear which is connected to a 34/22-h.p. variable-speed motor at 1,000/650 r.p.m. The gear gives a speed reduction of 120 to 1, thus giving a final speed of between 1·6 and 1·04 r.p.m. A hand-operated barring gear is fitted to the driving-gear for turning by hand in the event of a power failure.

The kiln is lined throughout with 8-in. thick firebricks, the first 46 ft. being first-quality firebrick with an alumina content of 60 per cent.; the clinkering zone for a length of 33 ft. is lined with firebrick having an alumina content of 70 per cent.; and the remainder of the kiln at the outlet end is lined with firebrick having an alumina content of 47 per cent. The outlet end is in a movable hood through which the clinker is discharged to a rotary cooler which is also lined with firebrick. On the kiln side of the hood is a floating-type air-sealing ring, while on the front of the hood are attachments for the firing-pipe of the oil-burning equipment, inspection windows, and cleaning doors. The fuel oil is pumped from storage tanks into a 5,000-gall. tank above the firing platform, from which it gravitates into a primary oil-heater and then through a heating filter connected to the suction side of a constant-pressure rotary pump which discharges through a superheater to the burner-pipe. On the superheater is a pressure-relief valve which passes oil back to the primary heater should the requirements of the kiln be varied. Duplicate heating, filtering, and pumping plant is installed so that the supply of fuel can be maintained when cleaning and maintenance are carried out. The pumps are driven by 3-h.p. motors at 1,400 r.p.m. All oil-circulating pipes are jacketed and heated by hot water from a calorifier; thermostatic controls are fitted to both oil and water heaters, and an oil-flow meter is fitted in the feed-pipe to the kiln.

The firing equipment is mounted on a travelling carriage with a flexible connection from the oil supply, and also from the water supply for cooling the jacket of the burner. On the same carriage are an oil pump, filter, and heater, and also a centrifugal fan, running at 2,800 r.p.m. and driven by a 20-h.p. motor, for supplying the primary air for atomising and burning. Controls are provided for regulating the quantity of oil, the velocity and quantity of air, and for upward, downward, and sideways movement of the carriage. The kiln-hood is over a brick structure with a chamber, in the form of a chute, terminating with a cast-iron water-cooled casting over which the clinker falls to the cooler; steel-angle corners, stays, and tie-rods give rigidity to the structure.

The cooler is directly under the kiln. It is 5 ft. 9 in. diameter by 56 ft. long, and at an inclination of 3·5 per cent. It is supported on two cast-steel tyres 8 ft. 3 in. diameter by 8 in. wide supported on cast-steel rollers 2 ft. 7½ in. diameter by 10 in. wide shrunk on to forged-steel shafts which revolve in water-cooled oil-lubricated bearings lined with white metal and supported on steel bedplates. An air-sealing ring of the floating type is fitted to the inlet end of the

cooler, the stationary part of the ring being fixed to the brickwok. For turning the cooler at 2·5 r.p.m., a cast-steel spur-ring of 10 ft. 8 in. diameter having 146 teeth at 2¾ in. pitch is bolted to the shell and engages with a spur-pinion 20 in. diameter having 23 teeth and which is keyed to a totally-enclosed spur reduction-gear having a speed range of 60 to 1. The gear is connected by a flexible coupling to a 20-h.p. motor at 970 r.p.m. On the outlet end of the roller bedplate are two rollers for resisting the axial thrust of the cooler. The first 40 ft. of the cooler is lined with 4½-in. thick second-quality firebrick with an alumina content of 35 per cent. ; the last 13 ft. 6 in. of this part is fitted with cast-iron lifters bolted to the cooler shell, and the next 11 ft. 6 in. of the shell is fitted with mild-steel lifters.

The clinker is discharged from the cooler through a chute to either of the two enclosed vertical bucket elevators, each at 65 ft. centres and having 12 in. wide steel buckets attached by links to a double strand of cable chain ; each elevator is driven through a spur-wheel keyed to the head-shaft by a reduction-gear transmitting 8 h.p. at 1,400/120 r.p.m. The clinker is discharged at the head of the elevator into a totally-enclosed automatic weighing machine of the rotary-bucket type, which discharges the clinker into a steel chute which transports it into the main stores building.

The kiln and cooler are in a reinforced concrete structure built as a lean-to at the side of the main store building and measuring 147 ft. 9 in. long by 32 ft. 10 in. wide by 53 ft. 6 in. to the eaves ; the roof and the side to a height of 30 ft. are covered with protected-steel sheeting. A reinforced concrete annexe at the firing end of the kiln, 29 ft. 6 in. long by 32 ft. wide by 28 ft. 6 in. high, houses the firing apparatus.

Handling Gypsum.

Lump gypsum from the store is fed into a single-toggle jaw-granulator having a jaw opening of 16 in. by 10 in. ; this is rope-driven from the pitman shaft by a 20-h.p. motor at 725 r.p.m. The crushed gypsum falls into the boot of an enclosed-bucket vertical elevator at 49 ft. centres which discharges it into the main store building. The elevator is driven through spur-gearing keyed to the head-shaft by a 7-h.p. motor at 1,400/120 r.p.m. The gypsum-crushing plant is in a reinforced concrete framed lean-to structure at the side of the main store building and measuring 147 ft. 9 in. long by 27 ft. wide by 35 ft. 9 in. high to the eaves ; the roof is covered with protected-steel sheets, the sides and ends being open except on the stores side where there is a reinforced concrete retaining wall 12 ft.high. The area inside the building not occupied by the crushing plant is used as a store where gypsum is discharged direct from railway trucks.

Cement Grinding.

Clinker and gypsum are taken from the main store building by the overhead grab-crane and discharged into reinforced concrete bunkers over the feed-tables of the mills. These bunkers are divided into three compartments, two of which, each measuring about 17 ft. 6 in. by 10 ft. at the top, have a capacity of 100 tons of clinker each, and the third, measuring 17 ft. 6 in. by 6 ft. 3 in. at the top, has a capacity of 35 tons of gypsum. The feed arrangements and the mills and dust-

collecting equipment have been described when dealing with the raw meal and clinker grinding.

Cement Storage and Packing.

Two 90-mm. pipes between the two-way valves at the outlet of the Cera pumps convey cement pneumatically from the outlet of the mills to the top of the silos, where it is distributed through two-way hand-operated valves into three reinforced concrete silos, each 26 ft. diameter by 69-ft. high and having a capacity of 1,500 tons. The air which carries the cement is vented from each silo through six fabric filter-stockings each 10 in. diameter by 6 ft. long. The base of the silo is in the shape of a letter W with two troughs at the bottom which connect with the outlet of the silo for the discharge of the cement through a valve. On each side of each trough and in each trough are porous plates which, when supplied with compressed air, assist in discharging the cement through the valves through which it is discharged into a 20-in. wide air-slide conveyor which takes the cement to either of two elevators supplying the packing machines. The air-slide conveyor is in the form of a rectangular trough with a loose cover; horizontally and midway up the sides of the trough, and extending from end to end of the conveyor, are porous plates through which air (supplied by two centrifugal fans, one at each end of the conveyor and driven by 3-h.p. motors at 2,800 r.p.m.) filters from the lower part of the casing into the upper part of the casing which contains the cement. The air mixes with the cement which is then in a quasi-liquid state and readily flows along the conveyor trough which is at an inclination of 4 per cent. On the cover-plate of the casing at frequent intervals fabric filter-stockings are fitted to release excess air. In the packing department are two bag-filling machines, which are supplied from the silos by the air-slide conveyor. The discharge from this conveyor is into either of the elevators which are 16-in. wide totally-enclosed bucket-elevators 38 ft. long. These elevators take the cement to the first floor of the building, and they are driven through a spur-gear keyed to the head-shaft by an 8-h.p. motor at 1,400/120 r.p.m. From the elevators the cement is discharged through a steel chute into a 24-in. diameter sieving-conveyor 17 ft. 9 in. long driven by an 8-h.p. geared motor at 970/31 r.p.m. The sieving-screw is directly over, and delivers into, a steel hopper which has a flanged outlet for connection to a three-spout automatic machine which fills valve bags with 94 lb. of cement. Should bag-filling be interrupted and the hopper become full, the cement can be delivered to a reinforced concrete bunker with a capacity of about 60 tons, and which discharges into the boot of the elevator feeding the sieving-screw, thus forming a closed circuit. The bag-filling machine is driven by a 20-h.p. motor at 1,400 r.p.m. and has a capacity of about 35 tons per hour.

The full bags fall from the machine on to a reversible conveyor having a 28-in. wide belt 23 ft. long, from which the bags can be discharged at either end for loading directly into railway trucks or alternatively into motor lorries. The conveyor is chain-driven by a 5-h.p. geared motor at 970/74 r.p.m. situated in a trench in the floor. Under the conveyor is an 8-in. diameter screw-conveyor which collects the spillage from the machine and the bag conveyor and returns the

cement to the boot of the elevator feeding the sieving-screw; this screw-conveyor is driven by a 2-h.p. geared motor at 970/74 r.p.m. Provision is also made for loading large containers with loose cement.

An automatic dust-collecting machine is connected to each packing machine; this collector is similar to those in the mill house and has 51 filter-stockings 8 in. diameter by 11 ft. 6 in. long automatically shaken by a 2-h.p. geared motor at 970/74 r.p.m. The dust deposited in the lower part of the filter casing is collected by a screw-conveyor and discharged through a rotary valve into the boot of the elevator feeding the sieving-conveyor; the collecting-screw and valve are chain-driven by a 2·5-h.p. geared motor at 970/74 r.p.m. The packing building is a two-story reinforced concrete structure 202 ft. long by 38 ft. wide by 36 ft. high to the eaves, with a floor at 19 ft. 6 in. above the packing-floor level. Along each side is a canopy over the rail and road loading-platforms. From first-floor up to the eaves the walls comprise reinforced concrete columns and 6-in. thick concrete blocks. The first-floor houses the elevator heads, sieving conveyor, and dust-collecting plant with space for storage of empty bags, and is served by a platform hoist; there is an access shaft from the first floor to the top of the cement silos. The roof of the packing plant is covered with steel sheeting.

Miscellaneous Services.

Compressed Air.—The compressed air for pneumatically conveying the raw meal, for conveying the cement from the Cera pumps to the silos, for aerating the cement at the bottom of the silos, and for general use, is supplied by three single-cylinder single-stage compressors. These machines have a cylinder diameter of 17½ in. and a stroke of 12½ in., and each delivers 530 cub. ft. of air per minute at a pressure of 60 lb. per square inch; they are rope-driven at 225 r.p.m. by a 120-h.p. motor at 950 r.p.m. Each compressor is provided with valves for automatically maintaining pressure. On the suction side of each compressor air passes through a filter before entering the compressor, and on the discharge side the compressed air passes through a water-cooler for removing oil and water before passing into the air receiver, which is 5 ft. 4 in. diameter by 16 ft. high, and has a capacity of 350 cub. ft. The compressors are in a reinforced concrete frame structure with concrete-block panels. The building is 52 ft. long by 32 ft. 10 in. wide by 22 ft. 2 in. high to the eaves, and has a gantry carrying a 10-tons 30-ft. span hand-propelled crane 18 ft. above floor level. Space is left for the installation of three further sets of compressors, and this building also houses the water-softening plant and circulating-pumps.

Fuel Oil.—Oil used for firing the kiln and raw-material dryers is received from railway tank wagons through flexible hoses to the main storage tanks. Three sets of pumps are installed, one with a capacity of 3,000 gallons per hour and driven by a 7·5-h.p. motor, and the others each having a capacity of 1,200 gallons per hour and driven by a 5-h.p. motor running at 480 r.p.m. The suction side of the pumps is connected to a common main so that any one or all three pumps can deliver to either of the two main storage tanks; an oil-flow meter of 3,000 gallons per hour capacity is installed in the delivery main. The two main

storage tanks are 25 ft. diameter by 30 ft. high; each has a capacity of 90,000 gallons. The three pumps used for delivering oil to these tanks can also discharge into the 5,000-gall. service tank of the kiln. A flow-meter of 3,000 gall. per hour capacity is installed in the main to the service tank. Two further pumps, each of 180 gallons per hour capacity and driven by a 1-h.p. motor at 940 r.p.m., are installed for transferring oil from the main storage tanks to the 1,000-gallons' service tank of the raw-material dryers; an oil-flow meter of 1,000 gall. per hour capacity is fitted to the delivery main. A filter is fitted to the suction side of all pumps. Float-switches are fitted in the service tanks for the dryer and kiln for automatically stopping and starting the pump motors.

Water.—Water is obtained from deep bore-holes on the site, from which water is pumped to a reinforced concrete storage tank. A supply is also taken to a softening plant for use in cooling coils, bearings, jackets of the air compressors, etc.; this supply gravitates from the service tank through the softening plant into a sump, from whence it is pumped to a tank on the roof of the granulating building. From this tank water is piped to the various cooling coils, etc., and returned to the sump for recirculation. The pumps are automatically controlled by float-switches in the service tank. Two pumps are installed for this service, each delivering 100 gall. per minute at a head of 140 ft. and driven by an 8-h.p. motor at 2,800 r.p.m.

Electricity.—Electric power is supplied by the Uganda Electricity Board from Jinja, 95 miles away, by overhead lines at 33,000 volts. Transformers in the sub-station supply current at suitable voltages for the motors. The three mill-motors are supplied at 3,000 volts, and the other motors at 415 volts; lighting is at 215 volts, single-phase.

Workshop and Stores.—The fully-equipped workshop is 81 ft. 6 in. long by 25 ft. wide by 16 ft. high to eaves; it has walls of concrete blocks and a steel roof; there are a machine shop, welding, blacksmiths', carpenters', and electricians' shops, and a tool store. The store building is similarly constructed and is 94 ft. 6 in. long by 45 ft. wide by 16 ft. to the eaves.

Proposed Cement Works in Honduras.

It is reported that the idea of building a cement works at San Pedro Sula is again being considered. Many public works and roads are now being built in Honduras, and it has been claimed that it is very desirable that the cement required should be made in the country.

Proposed New Cement Works in Turkey.

The Turkish Ministry of Commerce and Economy is considering a proposal of a Danish concern to erect a cement works in Turkey at a cost of £T400,000.

Vibrated-Mortar Cube Tests.

THE report of the Building Research Board for the year 1950 (London: H.M. Stationery Office. Price 4s.) states that comparative tests have been carried out by various co-operating laboratories on the vibrated-mortar compressive-strength test for cements. This test was introduced into the British Standards for cements in 1940. Some testers had, however, expressed doubt about the reliability of the method, mainly on the ground that some of the vibration machines made during the war were defective. A modified design and a more rigid specification have now been made, but since it may be some time before the new machines are generally available the performance of the existing vibrators was investigated by comparative tests at twelve laboratories.

The procedure was to prepare in each laboratory eighteen mortar cubes with three types of cement, namely, ordinary Portland, rapid-hardening Portland and high alumina. Uniform samples of the cements and standard sand were sent to the laboratories, and an officer of the Building Research Station was present during the tests. Six cubes were tested for each type of cement at 3, 7 and 28 days. The 3-days' and 7-days' cubes were tested at the various laboratories. The 28-days' tests were made at the Station.

Of fourteen machines, five of which were made to the new specification, all appeared to be capable of satisfactory performance. Calibration tests showed that, of twelve machines examined, three satisfied the Class A requirements of B.S. No. 1600: 1950 "Verification of Testing Machines," two satisfied Class B, and five Class C. Two machines could not be classified. The results show that the average coefficient of variation of the means of ten of the twelve laboratories is approximately 5·3 per cent.; this compares with 13 per cent. for previous tensile tests, and 16 per cent. for hand-compacted cubes. The variation was less when the 28-days' specimens from the different laboratories were tested in one machine than when the 3-days' and 7-days' specimens were made and tested in the different laboratories. This suggests that some of the variation is attributable to differences in laboratory conditions or to variations in testing machines.

The investigation has confirmed that the compressive-strength test on vibrated-mortar cubes is the best method of test yet tried, and that there appears to be no reason why this test in British Standards should not continue to be accepted.

Analysis of Flue Gases.

A CODE for the Sampling and Analysis of Flue Gases has been issued (price 10*s*. 6*d*.) by the British Standards Institution. The code has been prepared to guide industrial fuel consumers in selecting a procedure for sampling and analysing flue gases. It deals with flue gases from steam-raising appliances and heating boilers and also those produced in the manufacture of iron, steel, non-ferrous metals, pottery, refractories, heavy clay ware, food, cement, glass, certain chemicals and coal gas. "Flue gas" is defined broadly as the gaseous products arising from the combustion of fuel and of any additional carbonaceous matter in the material being processed. The code deals with the determination of the carbon dioxide, oxygen, carbon monoxide, hydrogen, methane, moisture, oxides of sulphur and oxides of nitrogen. It is stated that the methods described for the determination of carbon monoxide by palladium chloride, and the determination of oxides of sulphur and of nitrogen, are of recent introduction and may have to be modified as a result of experience in their use.

Part I of the code, which deals with methods of sampling, is devoted primarily to the general principles to be followed in order to obtain a representative sample; these principles apply no matter what the industry or the fuel-burning appliance may be. An account is given of the various ways in which a sample may be taken and convenient apparatus which can be used for this purpose is described; also, brief reference is made to more specialised sampling equipment. The code is concerned with the following types of sample: (*a*) "Snap" samples taken from a single point; (*b*) Average samples taken from a single point over a period of time; (*c*) "Snap" samples taken simultaneously from two or more positions in the flue; (*d*) Average samples taken from two or more positions over a period of time.

In some notes on the selection of sampling points, it is stated that consideration should be given to a number of factors before deciding on the exact point at which a hole should be made in the flue wall for inserting the sampling tube. These are: (*a*) The point should be where best mixing of the gas is probable. This can be expected to occur at the farthest point along the flue remote from the source of combustion. Stratification troubles are considerably reduced by turbulence resulting from the presence of fans, bends, changes in cross-sectional area, surface roughness, and other obstructions, and whenever practicable the sampling points should be downstream of any source of turbulence. Since there is less possibility of stratification occurring at higher velocities, it is an advantage to sample from a length of flue which has the smallest cross-sectional area, assuming that other conditions do not nullify this advantage. If trial samples indicate that mixing is poor, it may be possible, without interfering with the performance of the plant, to install an artificial obstruction in the flue. (*b*) An examination for air leaks upstream of the proposed sampling point is essential before sampling is commenced. Although dampers are often useful for promoting turbulence, they should be regarded as potential sources of in-leakage. (*c*) "Dead" spaces are generally found immediately downstream of dampers, orifice plates and other sharp-edged obstructions; also at the inner radius of bends, closed branches, pockets, and at sudden enlarge-

ments at any part of the flue walls. The main disadvantage of a "dead" space is that it imposes an unnecessary time-lag in sampling and does not follow the faster changes in composition. Air in-leakage in the vicinity of the "dead" space has a diluting effect, and even a small leak can render a sample useless. "Dead" spaces can be revealed by exploration of the flue with a pitot tube and a sensitive manometer, although this procedure is rarely necessary since prediction is fairly easy from a knowledge of the construction of the flue. (*d*) A symmetrical velocity distribution has the advantage that the relative velocities at different points in a cross section of the flue are more consistent with rate of change of flow than in the case of an unsymmetrical distribution. The relative velocity distribution of gas at a cross section of a flue just beyond an obstruction is not constant. Alteration in the rate of gas flow, or alteration of the position of a damper, can have a substantial effect on the relative distribution of velocities. This will increase the difficulties of taking a truly representative sample by the multipoint method, or by any system of sampling which depends on withdrawing a sample in true proportion to the velocity of gas at the sampling point. Hence, where multipoint sampling is necessary, the sampling point should be at the end of the longest straight length of the flue duct, because this gives the most symmetrical distribution.

It is pointed out that in selecting the method of analysis the operator must relate the accuracy of the analysis and of the sampling to the accuracy required for the investigation. For routine control of efficiency, the Orsat apparatus will usually

be suitable. Where greater accuracy is needed, resort should be had to more accurate types of apparatus, using mercury as a confining liquid, for example, the constant-volume apparatus and the constant-pressure apparatus. It may also be possible to utilise newer methods of accurate gas analysis involving flow methods or physical properties. The determining factor will be the extent to which the data ultimately obtained are rendered inaccurate by errors in the analysis. This factor will not be constant from plant to plant, since the flue gases may be responsible for a considerably greater proportionate heat loss in one case than in another. It is important that this estimate should be made at the outset, since the use of an unsuitable method leads to wasted time and labour and unreliable results.

Part II, which deals with methods of analysis, describes the portable Orsat apparatus for the determination of carbon dioxide, oxygen and carbon monoxide; the Haldane apparatus for the determination of carbon dioxide, oxygen, carbon monoxide, hydrogen and methane; the determination of moisture content by the gravimetric and physical methods; the determination of total oxides of sulphur; the determination of low concentrations of carbon monoxide by the iodine pentoxide method and the palladium chloride method; and the determination of oxides of nitrogen.

The many explanatory notes make the document a handbook as well as a code of recommended practice.

The Use of Fine-mesh Sieves.

A BRITISH Standard (No. 1796) entitled "Methods for the Use of B.S. Fine-mesh Sieves," has been published (price 3*s.* 6*d.*) by the British Standards Institution. The Standard deals with sieves between No. 5 and No. 300 in Tables 1 and 2 of British Standard No. 410. Notes are given on the preparation of samples and on hand and machine sieving and recommended types of dividers are illustrated and described.

Cement Supplies in Northern Ireland.

A NEW kiln is to be installed at the Magheramorne Works (County Antrim) of the Associated Portland Cement Manufacturers, Ltd., which, with existing capacity, will provide about 90 per cent. of Northern Ireland's total requirements of cement. The new kiln will be installed in about a year. The output at Magheramorne in the year 1951 was 165,000 tons, while the requirements of Northern Ireland are about 300,000 tons a year.

Cement Production in Norway.

THE production of Portland cement in Norway in the year 1951 exceeded 700,000 tons, compared with 583,000 tons in the year 1950. The production of cement in 1951 was nearly twice the production in the year 1938.

A Lime Works in Germany.

THE operation of the Rheinische Kalksteinwerke at Wulfrath, near Dusseldorf, one of the largest and most modern lime works in Germany, was described by Mr. Herman Lange (president of the German Lime Association) at the annual meeting of the U.S. National Lime Association held in September last year. The works has a capacity of 290,000 short tons of limestone and 61,700 tons of burned lime monthly. The over-burden is removed by shovels and is being used to form a dike for a 220-acre settling pond. About 80 per cent. of the stone is brought down by means of "coyote" holes, and the remainder is drilled with a face up to 75 ft. high. The coyote holes are driven about 30 ft. from the face, and the lateral tunnels are about 27 ft. long. The yield is about 4·3 tons of rock per pound of dynamite. The well-drill holes give a yield of about 5·3 tons per pound of explosive. Some secondary chuting is required, and the loading is done by 4·3 cu. yd. shovels into lorries, which are still generally used in Germany. There are two 230 ft. skips with tilting mechanisms which dump the materials from the lorries to grizzly feeders ahead of the two 71 in. by 55 in. primary jaw crushers. Their combined capacity is about 1,200 tons per hour. The rock then goes to two secondary crushers and to a screening and washing plant.

The lime plant consists of two Hoffmann kilns and 18 shaft kilns. The Hoffmann kilns are old, but there are still many of them in use as they can burn a low grade of coal mixed with lignite, and the chemical industry prefers this type of lime. Each kiln has a capacity of 163 short tons daily. The shaft kilns include four new Seeger mixed-feed kilns which are charged with alternate layers of coke and limestone in such a way that the coarser stone goes to the centre and the fine stone to the periphery. These kilns are 13 ft. interior diameter and 76 ft. high. Each has a capacity of 99 short tons daily, based on pure CaO, and a fuel rate of 1,962 B.T.U.s per lb. These kilns are fed with 10 per cent. 2⅜ in. to 4 in. and 90 per cent. 4 in. to 8 in. stone. Six of the other shaft kilns have elliptical cross-sections with an area of 75 sq. ft. and a height of 60 ft. and are gas fired. The output of each kiln is 77 short tons daily with a fuel rate of 2,439 B.T.U.s per lb.

Hydrators are not used in Germany. The hydrating is done in mortar mixers of 0·65 and 1·3 cu. yd. capacity. The time for hydrating a charge is 11 minutes. Rejects are sold as agricultural lime and for the production of high-strength artificial hydraulic lime. Packing of the finished product is done by valve bag packing machines.

In Germany the industrially-consumed limes and limestones are invariably sold directly to the respective industries, while building limes are distributed by wholesalers. Agricultural lime is distributed by a central sales organization which sells the product to farmers at the same price at any railway station within the Federal German Republic. At present farmers spread their own lime, but Mr. Lange stated that producers are interested in learning more about the American practice of having the spreading done by the lime companies or by contractors.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A Mechanical Vibrator for Test Sieves.

IT is an advantage when making a grading analysis of sand or stone to stack the sieves in tiers, pour the material into the top sieve, and agitate all the sieves at the same time, instead of manipulating each sieve by hand separately. The machine in *Fig.* 1 was developed for this purpose by British Railways (Western Region) and can take eight 8-in. diameter sieves or six 12-in. diameter sieves, a cover, and a collecting pan. It is of simple construction, has few moving parts, is quick in action, and has been in satisfactory operation for a year. The whole area of each sieve is used and wear of the sieves is thus reduced.

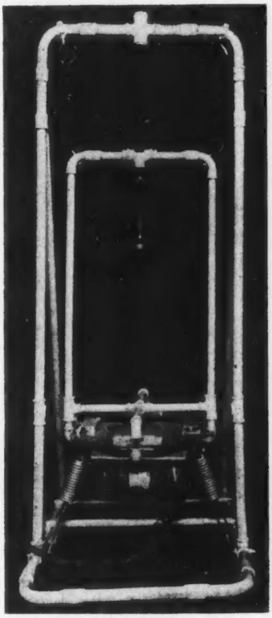
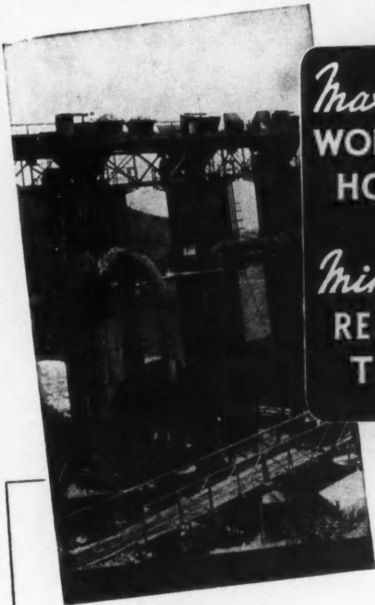


Fig. 1.—Sieving Machine.

The sieves (not shown in *Fig.* 1) are held in an inner frame suspended from an outer frame by four 2-in. diameter helical springs 6 in. long. The tension in the springs is adjustable. Below the inner frame is a variable-speed 37-volt 160-watt electric motor, at both ends of the shaft of which is an eccentric weight. The weights are out of phase by 90 deg., and set up a compound vibration which shakes the particles of the material being tested around the sieves in a circular motion, while the sieves undergo also a vertical vibration. Both motions are simple harmonic vibrations, the maximum amplitude being about 2 mm., and, due to the difference at the end of the motor shaft, a rocking motion takes place in the vertical and horizontal planes.

To test the performance of the machine, 200 grammes of sand were sieved on the machine for varying times, and the weights retained on each sieve measured. The sample was thoroughly remixed before each sieving. Constant results were reached in about eight minutes, but after five minutes the results differed on the average by only 0·14 per cent. from the results obtained after 20 minutes. As results are generally required only to the nearest whole number it is found that sieving for five to fifteen minutes, depending on the shape of the particles, gives results that are sufficiently accurate. The results are well within the limits specified in British Standards. To achieve the same results by a trained operator using the manual method requires about 45 minutes.

LIME KILNS



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